WinFS Replication

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WinFS Synchronization & Caching Team

Mission: *Provide a state-of–the-art synchronization platform integrated into and leveraging WinFS in support of diverse applications requiring peer-to-peer replication for data sharing, high-availability, and offline access.*

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Lev Novik – Architect

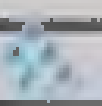
Talk Outline

This morning:

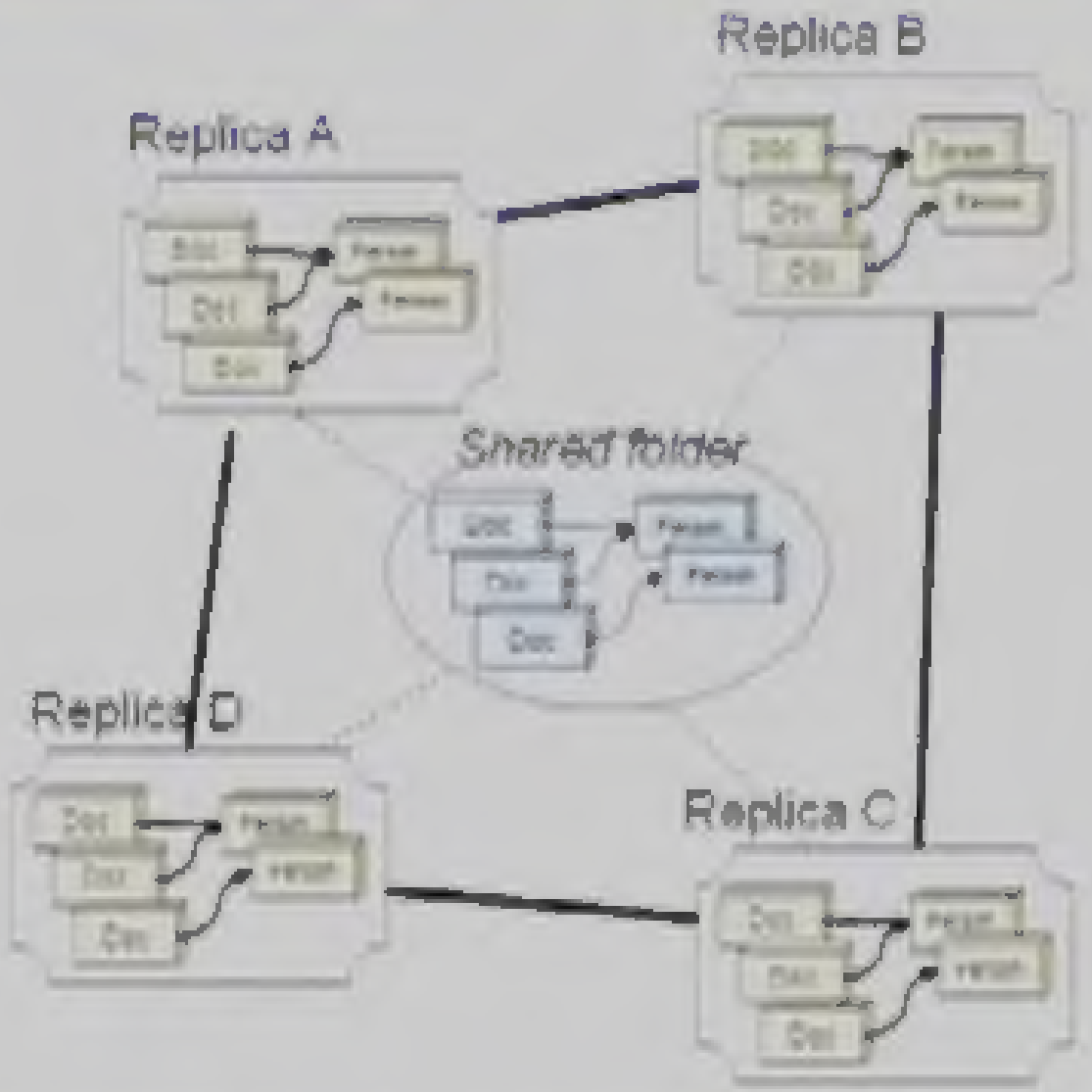
- Goals and requirements
- Change units, versions, knowledge
- Update propagation
- Conflict detection and resolution

This afternoon:

- Filtered sync
- Meta-data cleanup
- Open Issues



Goal: Replication of WinFS Folders



WinFS Synchronization Requirements

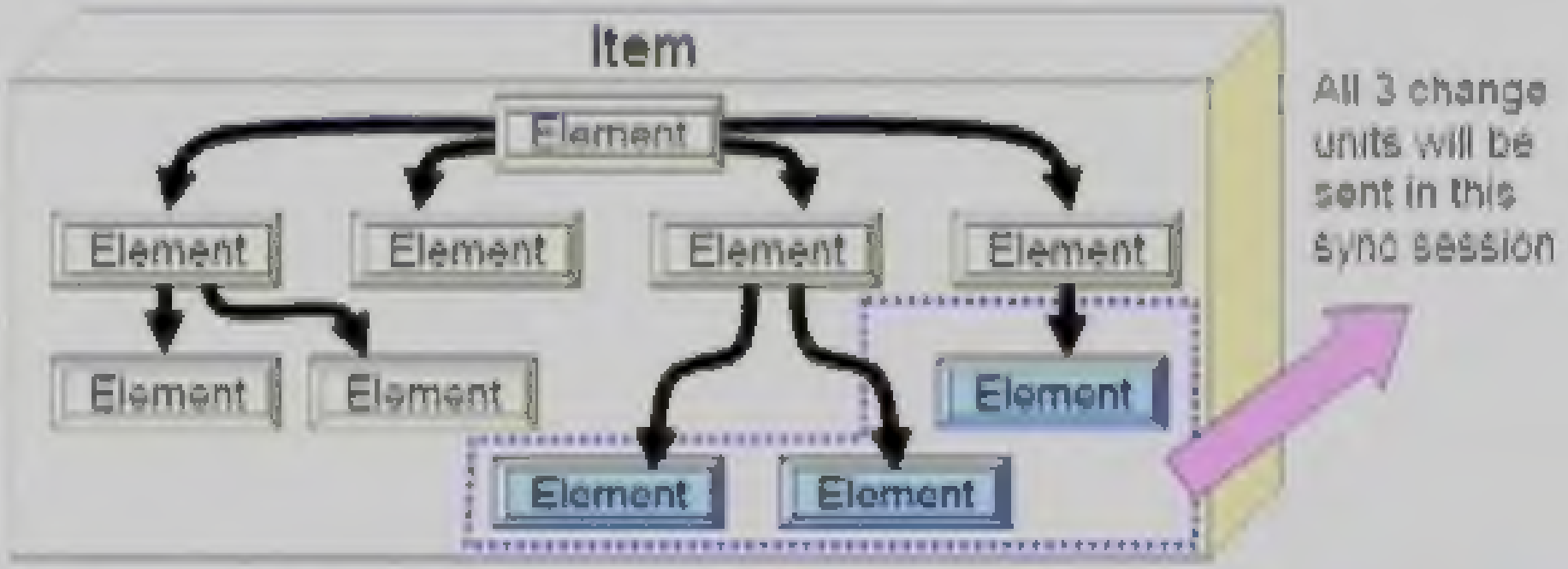
- Allow multi-master updates
- Support peer-to-peer topologies
- Operate at the level of WinFS Schema
- Permit configuration of "what" and "when" to sync
- Detect and handle conflicts during synchronization
- Accommodate varying network characteristics: intermittent connections, slow networks, offline
- Provide out-of-the-box "zero admin" manageability, resilience, and ease of use
- Guarantee convergence, even in "unmanaged" environments

WinFS Synchronization – Approach

- Read-anywhere/update-anywhere model
- Pair-wise reconciliation between replicas
- User-defined topology and schedule
- "Net Changes" of WinFS items/folders are conveyed, not individual actions
- Adapters for replication with non-WinFS machines, services, and devices (*not discussed in this talk*)

Items vs. Change Units

- Item = granularity of consistency
- Change unit = granularity of update, propagation, and conflict detection
  - elements or fields of elements



Versions of Changes

- Each change has a globally-unique id (version)
- Version = ID of the replica making the change + replica-specific number
  - Replica IDs are GUIDs
  - Replica-specific number is ever-increasing at the replica
  - e.g. A5, B2, C7
- Version of change unit is version of last change applied to that element
  - e.g. i.c: A5
- Versions only used by synchronization protocol; not visible to WinFS users

Knowledge for Update Propagation

- Knowledge = concise description of the set of changes received by a replica
  - knowledge depends only on local database
  - not pair-specific: not "what I have received from you"
- When requesting changes, specify
  - Current knowledge (i.e. "*don't send these*")
  - Filter (i.e. "*only interested in these*")
- When enumerating changes
  - Return change units and tombstones not covered by requester's knowledge
- When conveying changes, specify
  - Version of the change
  - The change itself
  - 'Made with' knowledge – for conflict detection
  - 'Learned' knowledge – not to send them again

Knowledge Abstractly

Main operations on knowledge:

- Test if a given knowledge covers a given change
  - "Does he already know about this change?"
- Add a change version to one's knowledge
  - "I just learned of a new change."
- Merge one knowledge with another to produce combined knowledge
  - "I knew this and he knew that, and now we both know this."

Knowledge Implementation

- Version vector = set of (replica GUID, replica-specific number) pairs
- Semantics: "all versions authored by this replica up to this number"
- Exceptions needed for changes received out-of-order
- Includes every replica that ever made a change

Protocol Using Knowledge

Machine A

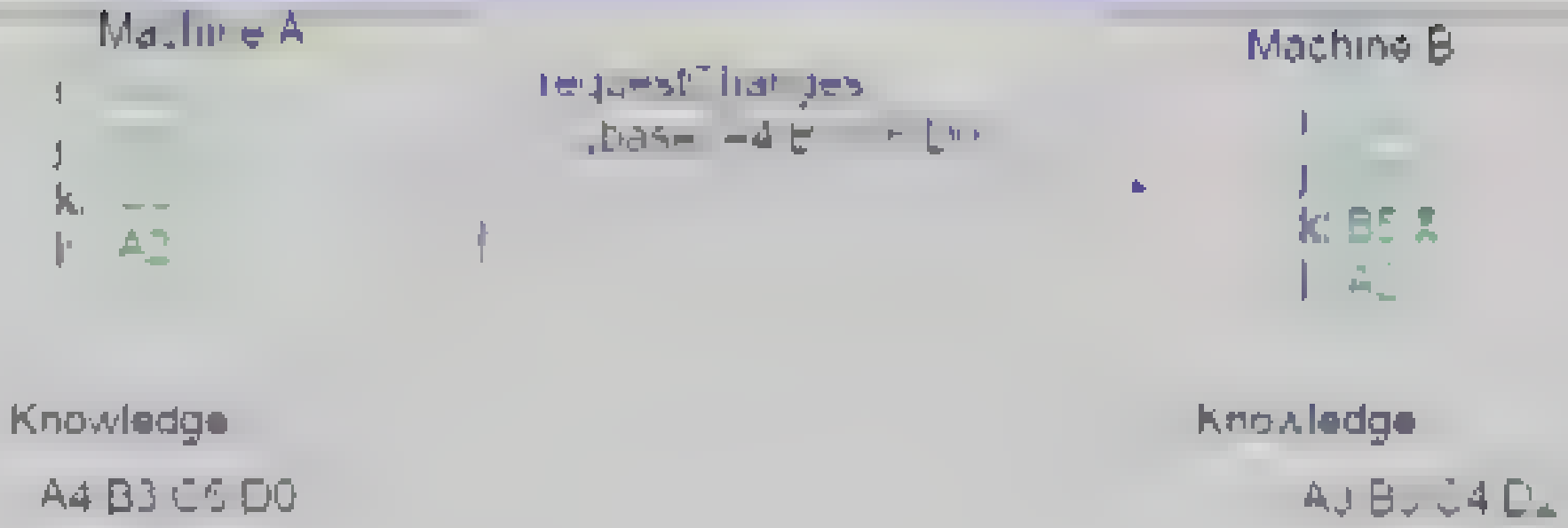
Machine B

Knowledge

A4 B3 C6 D0

Knowledge

Protocol Using Knowledge



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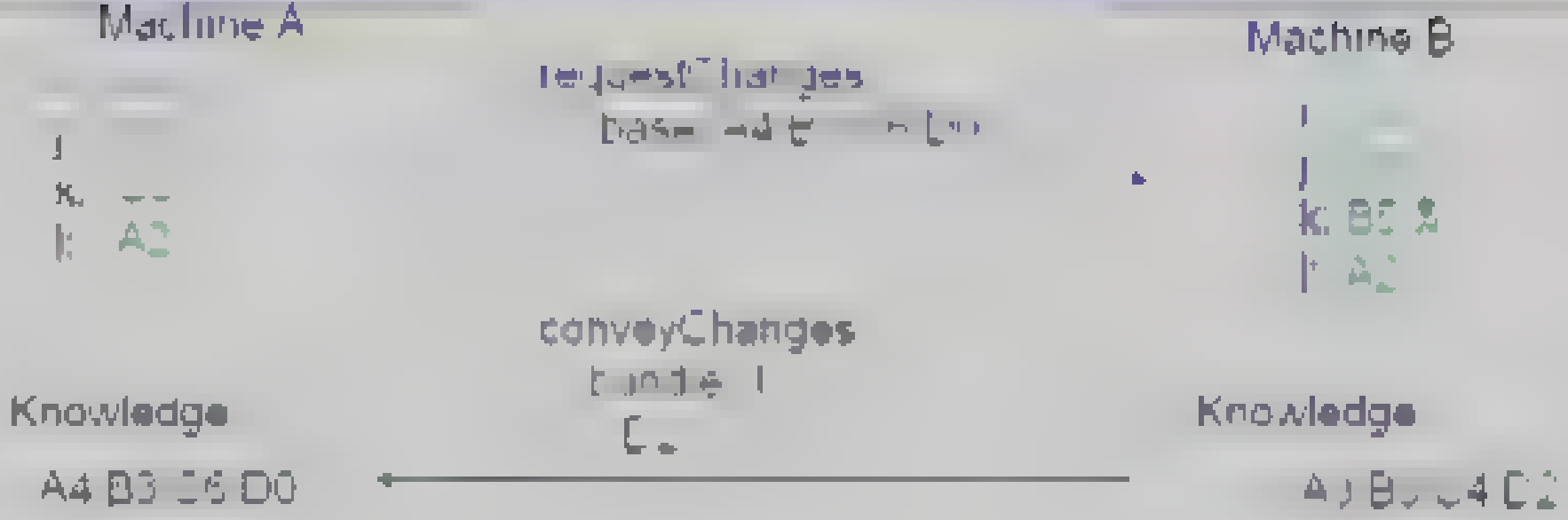

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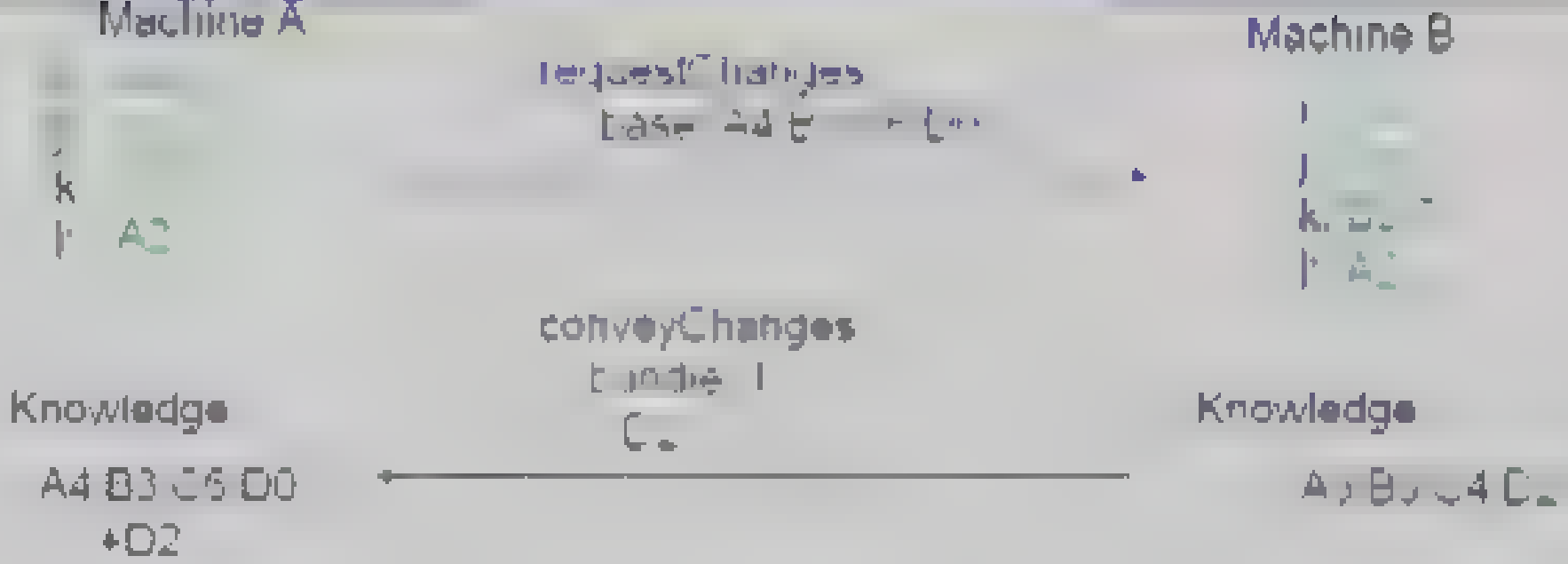

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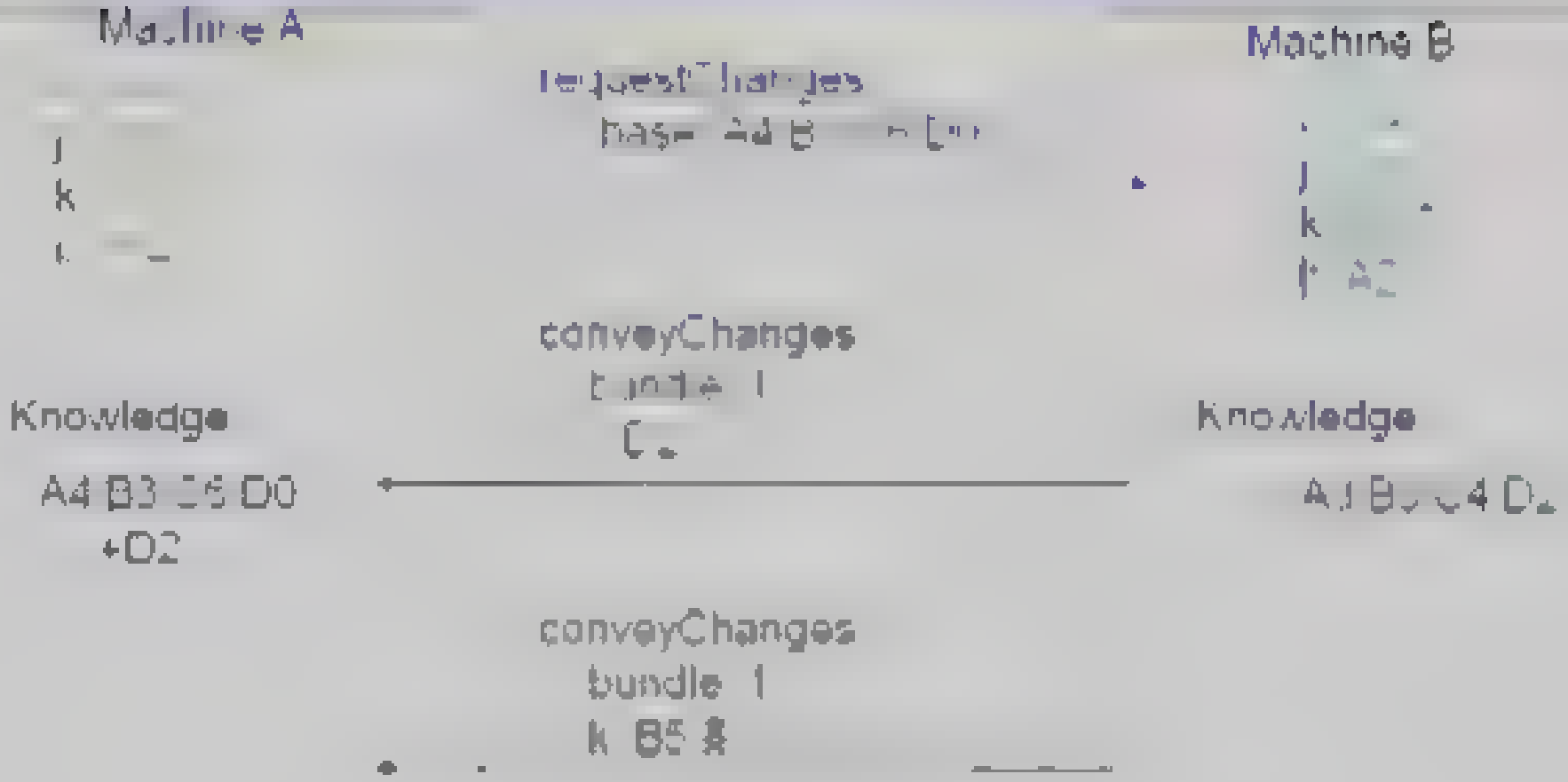

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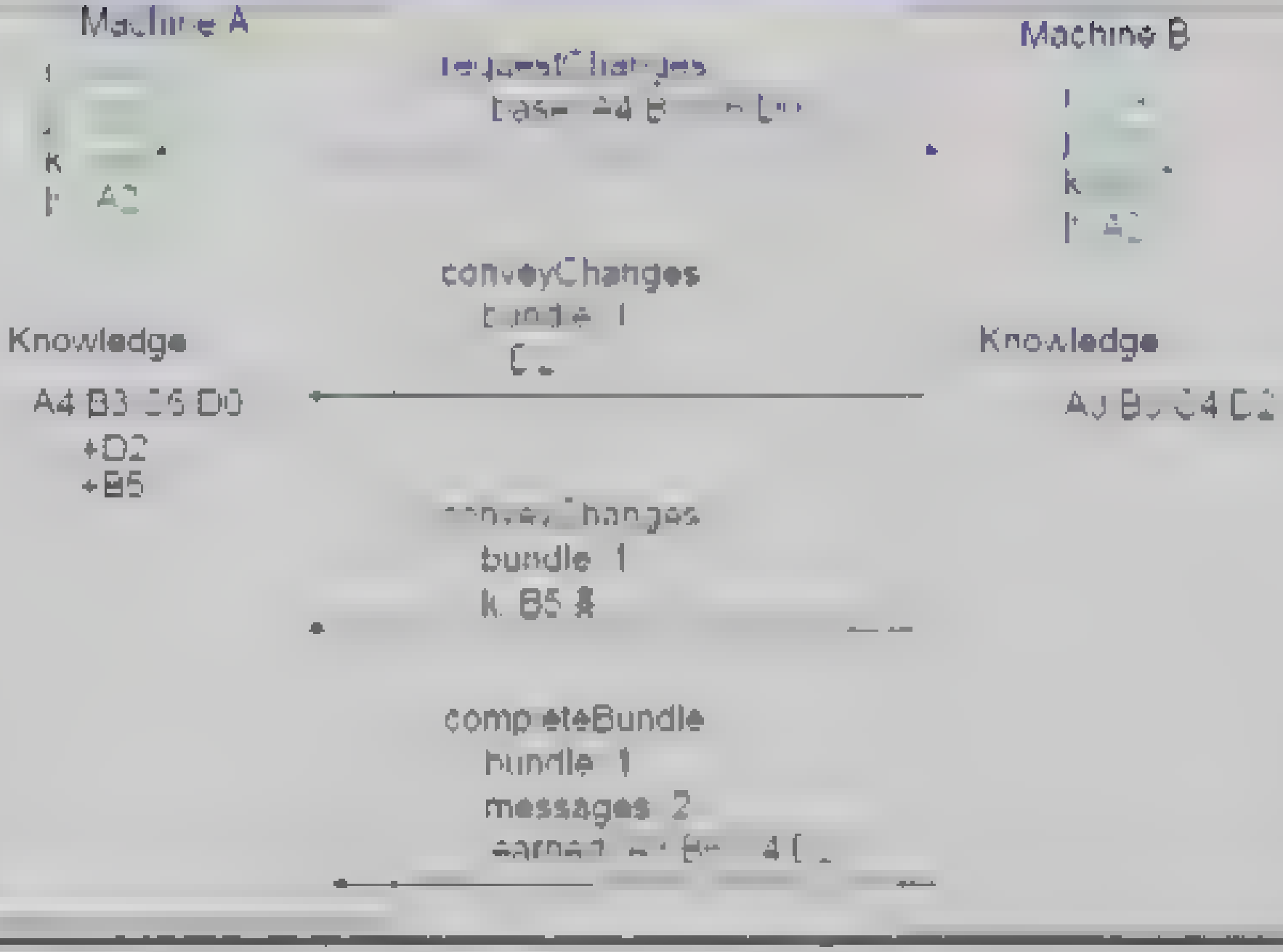


Sync Protocol : Things Not Shown

- Conflict detection and resolution
  - [illegible] concurrent up[illegible]
  - [illegible]ng or automatica[illegible]
- Batching
  - [illegible]
  - [illegible]
- Topology optimizations
  - [illegible]
- Filtering
  - [illegible]
- Meta-data cleanup
  - [illegible]
  - [illegible]

Conflict Definition

- Two changes conflict iff

  (1) the semantics of the changes are incompatible

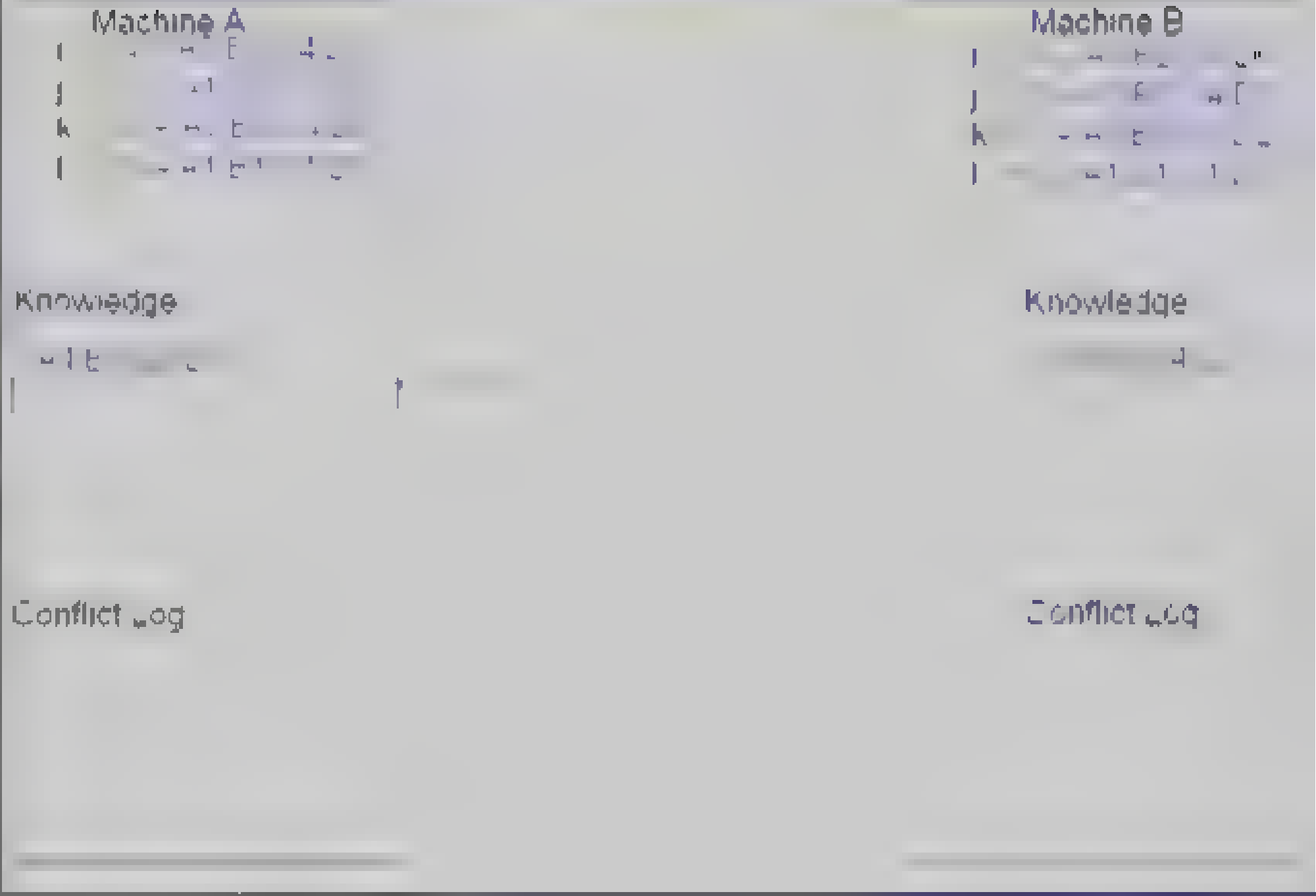
  (2) the changes were performed concurrently
  (without knowledge of each other)

Conflict Detection using Knowledge

- "Made with" knowledge = knowledge of replica when change was accepted

- Changes C_1 and C_2 are concurrent iff
  (1) C_1 version not in C_2 madeWithKnowledge and
  (2) C_2 version not in C_1 madeWithKnowledge

Protocol with Conflict Handling



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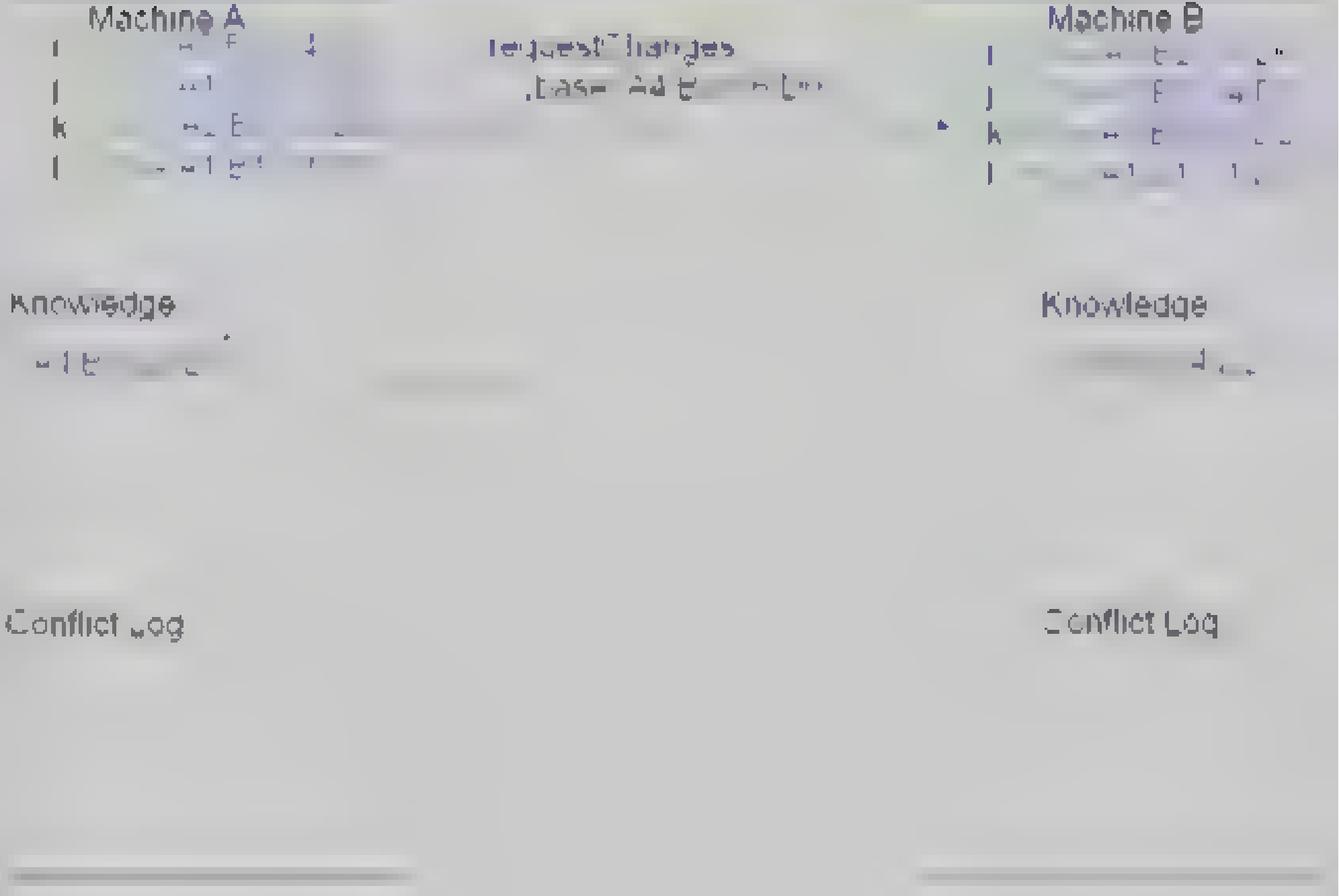

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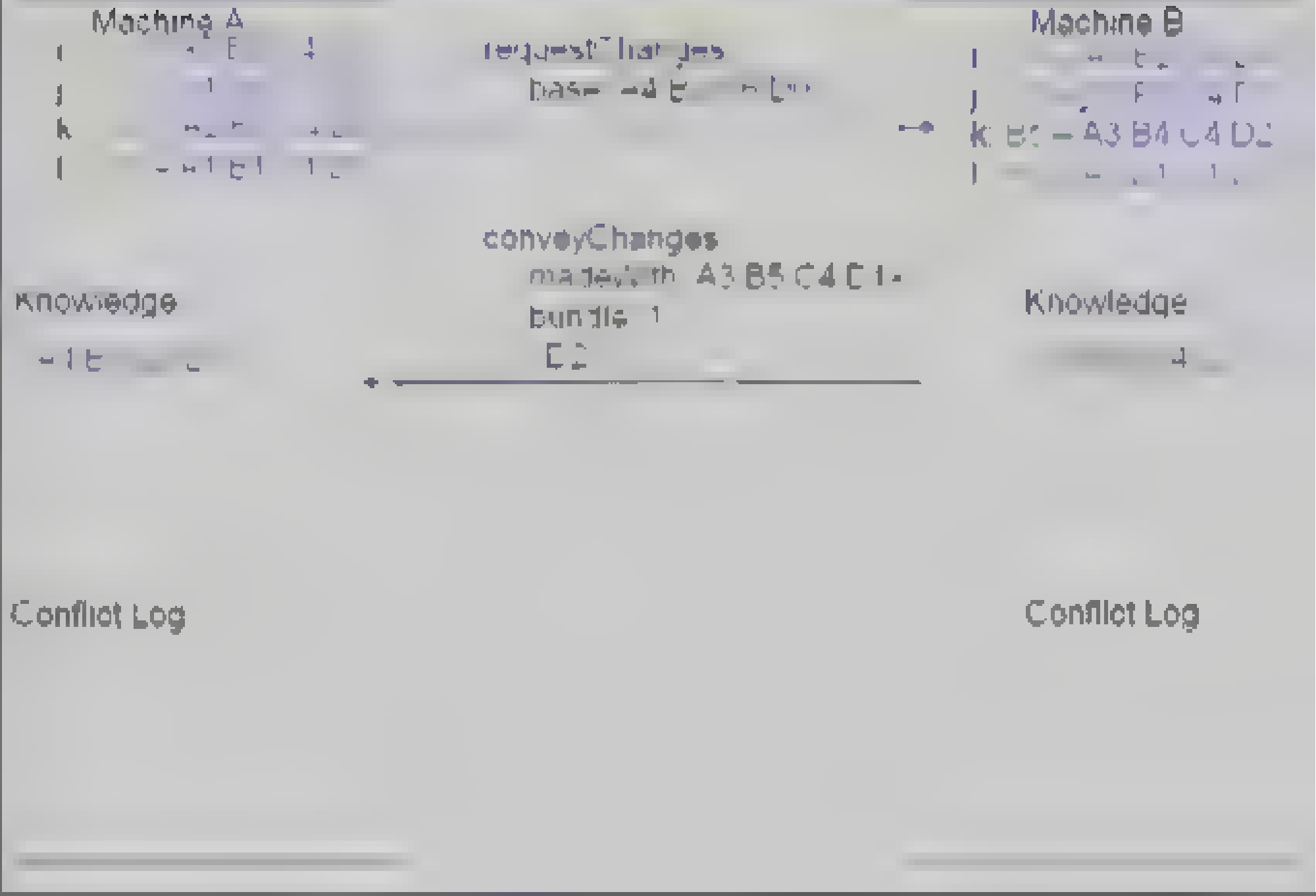

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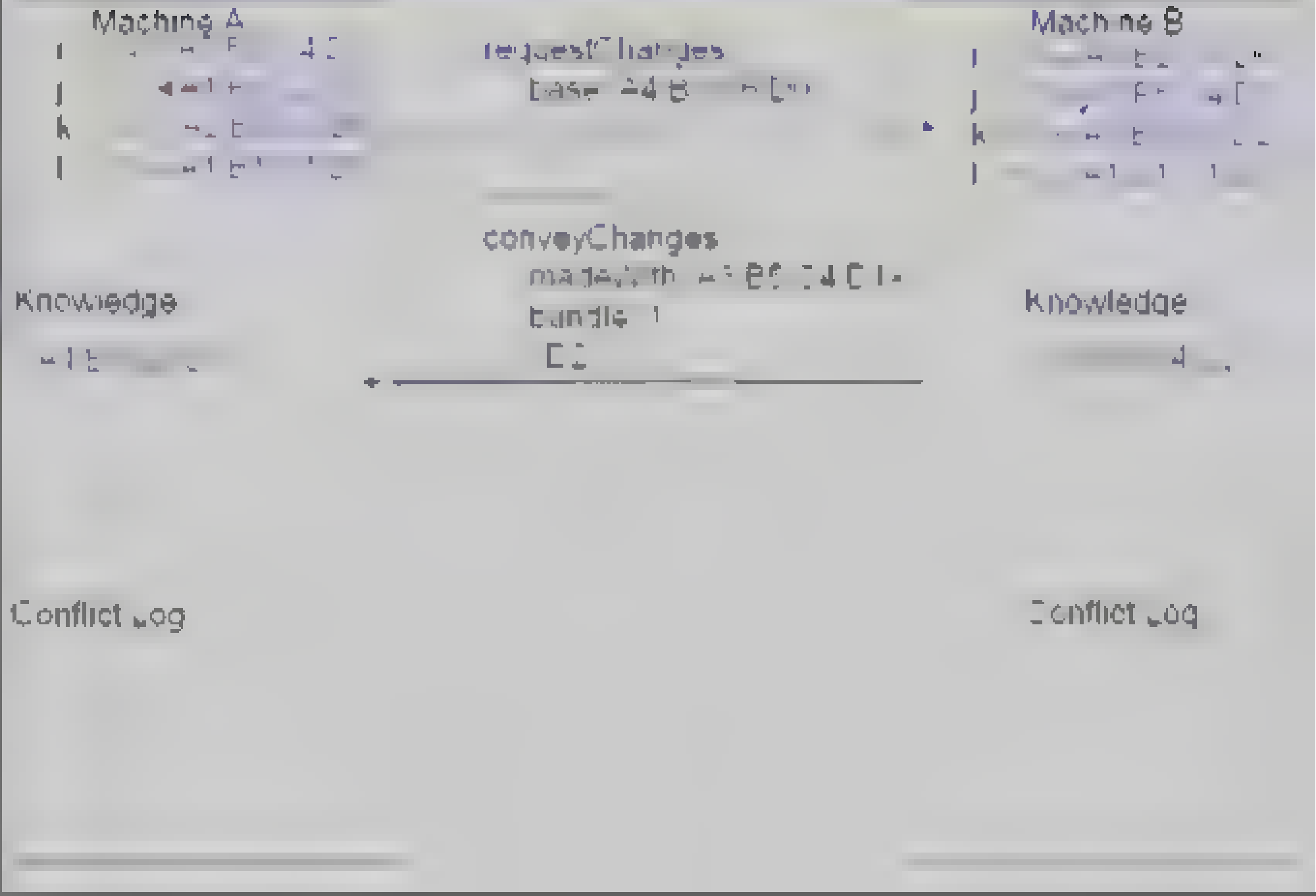

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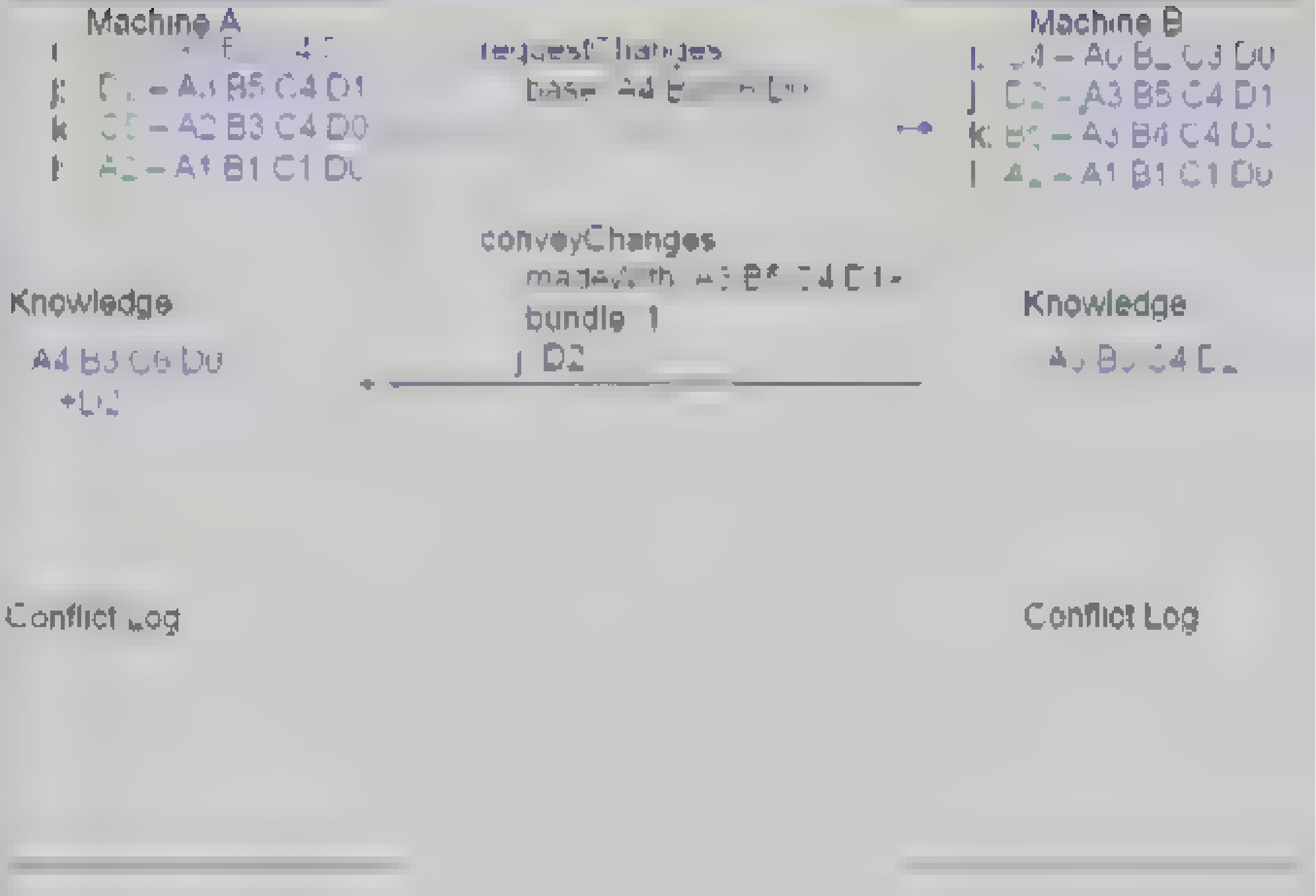

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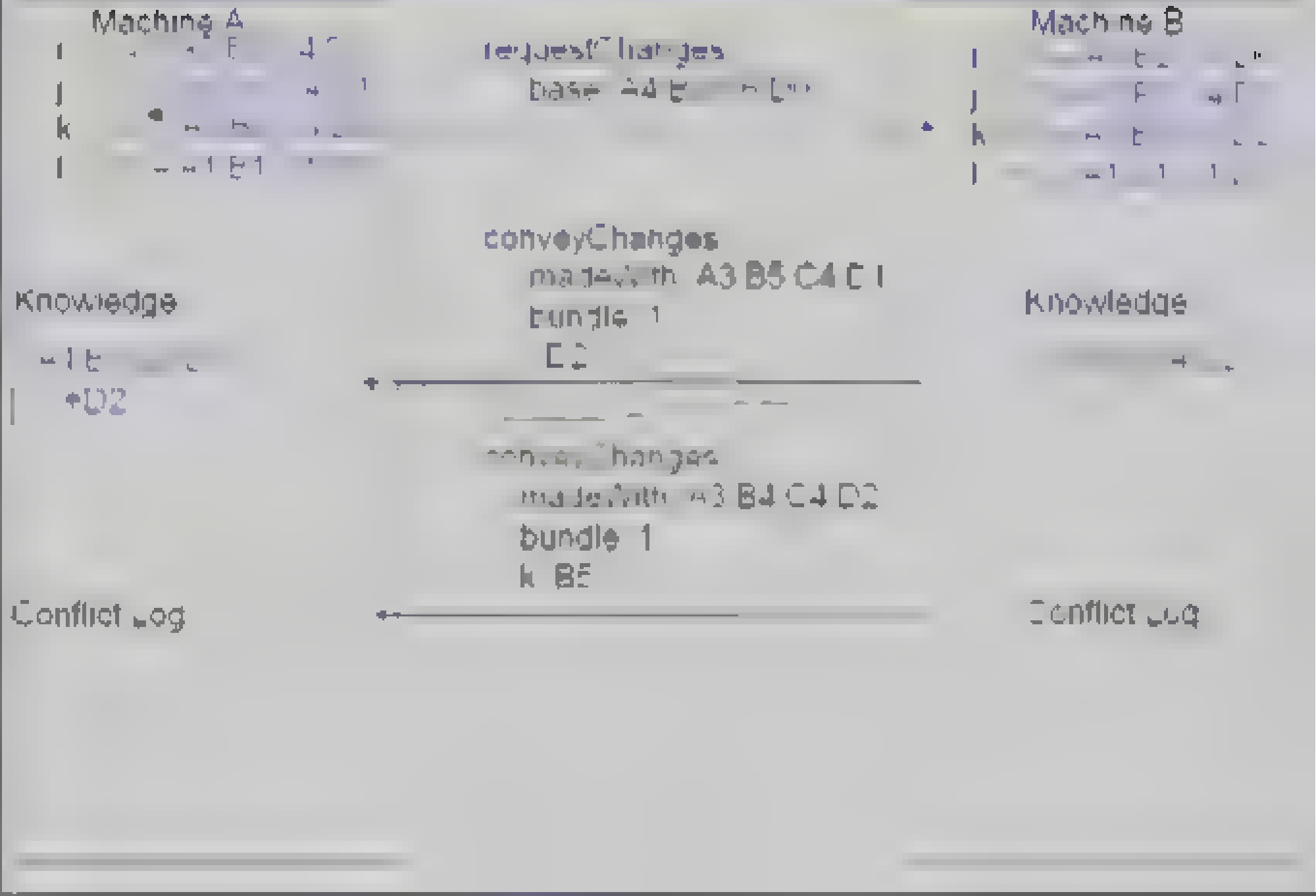

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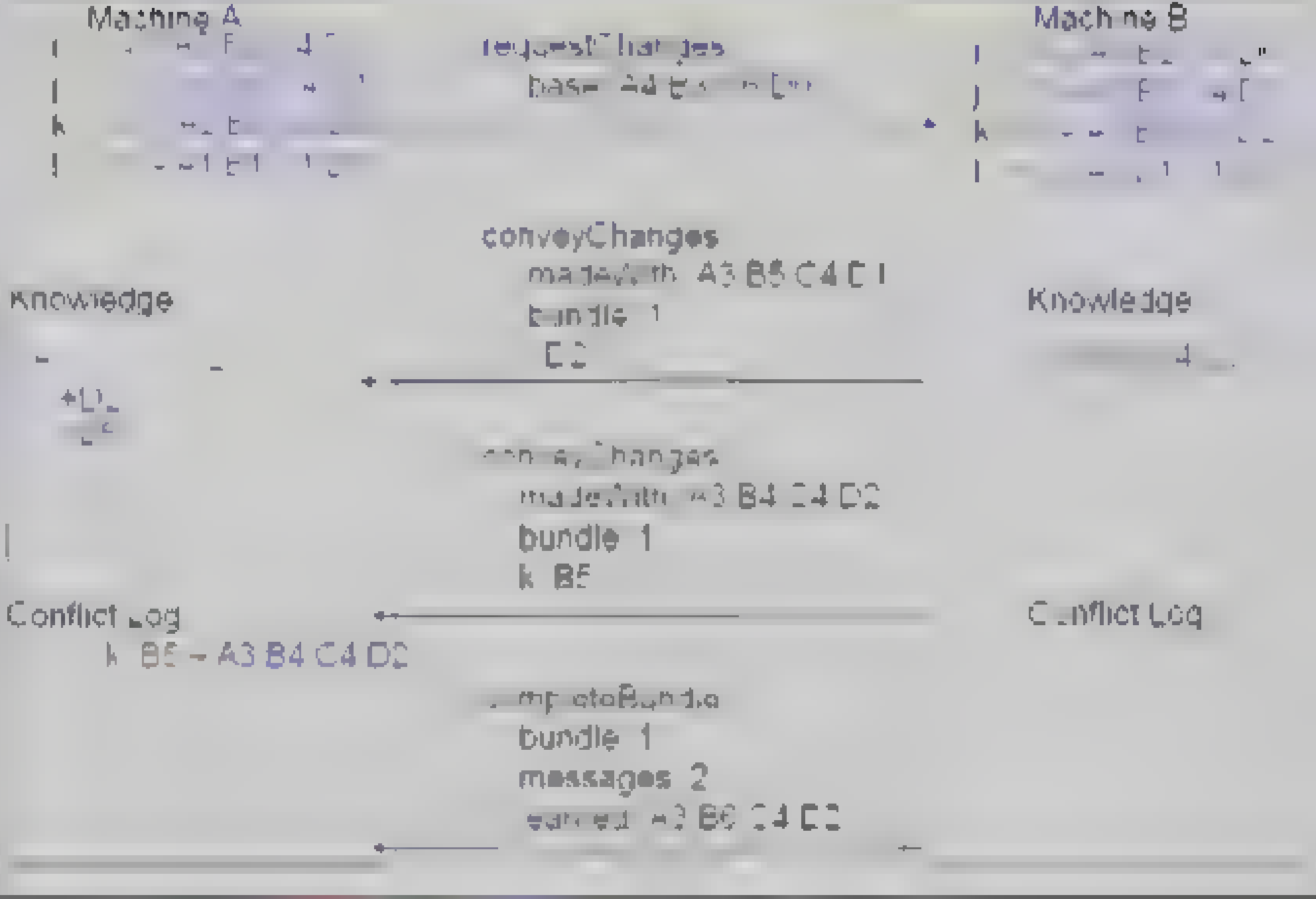

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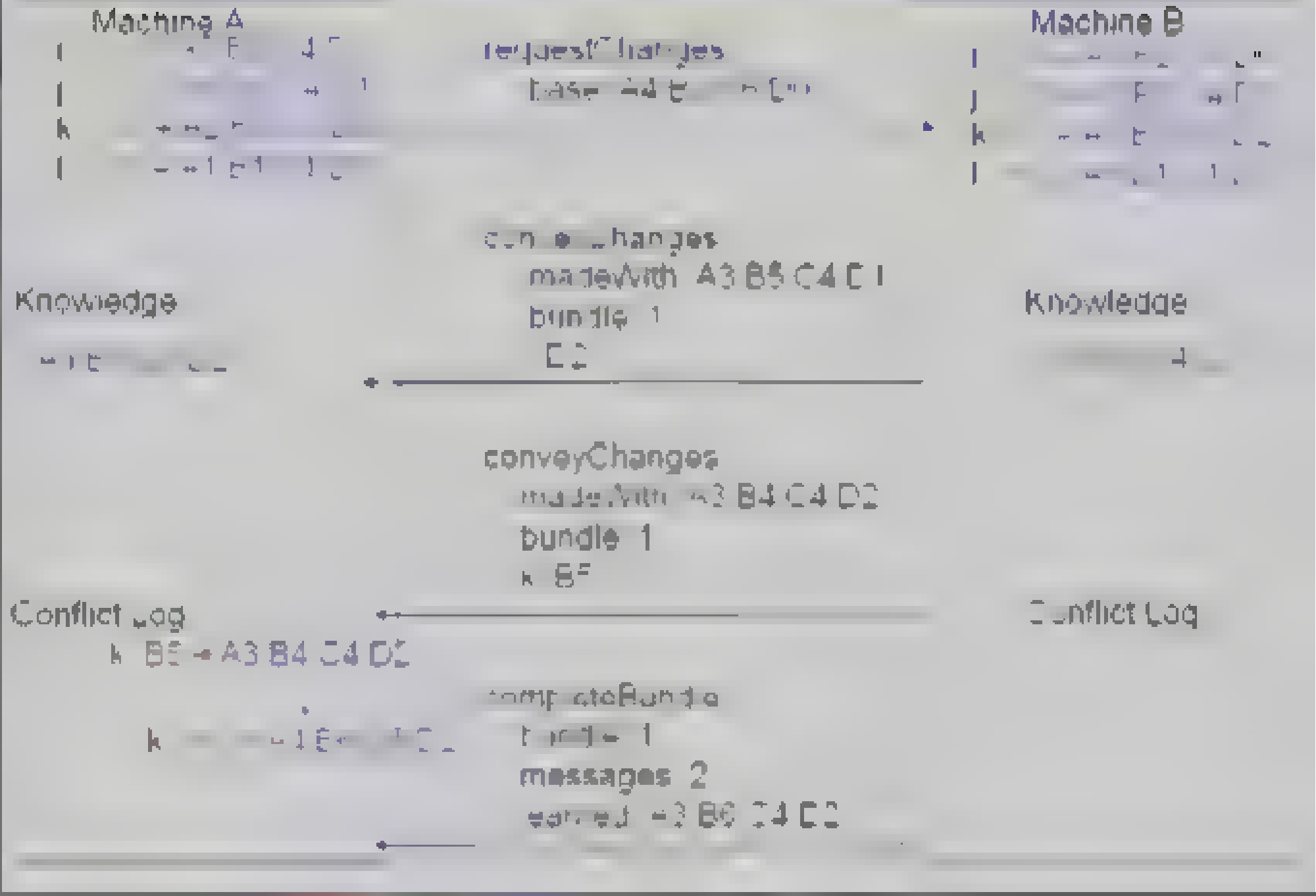

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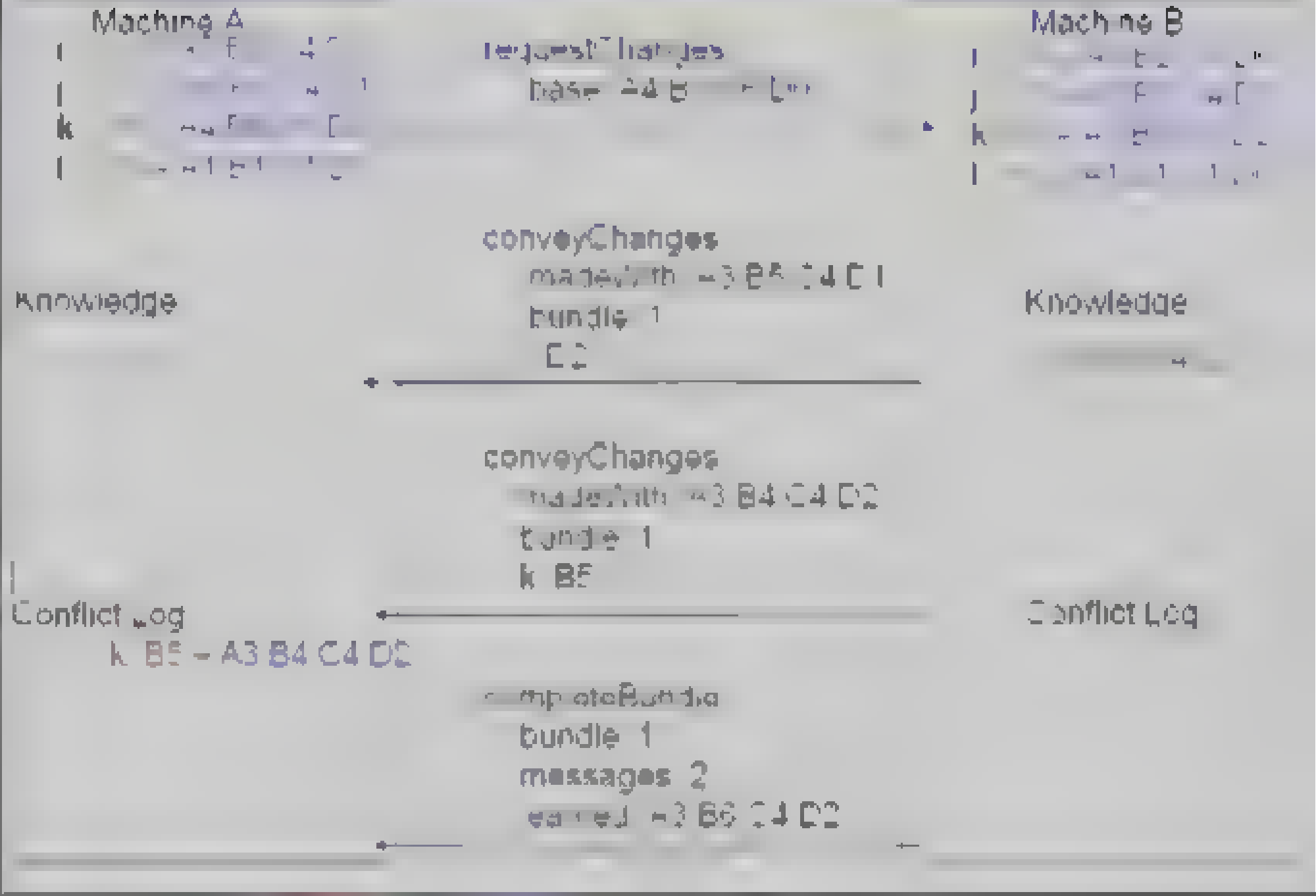

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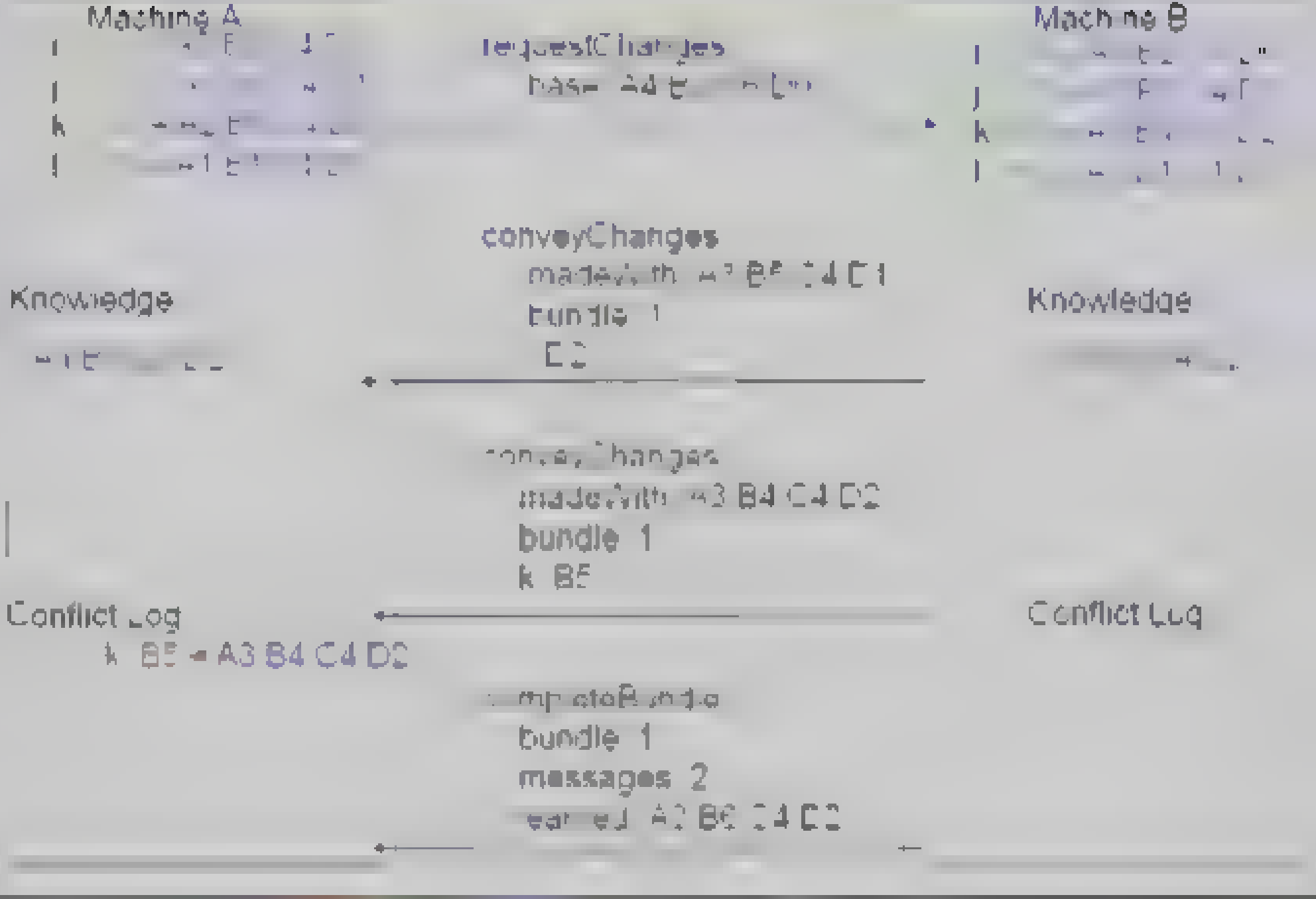
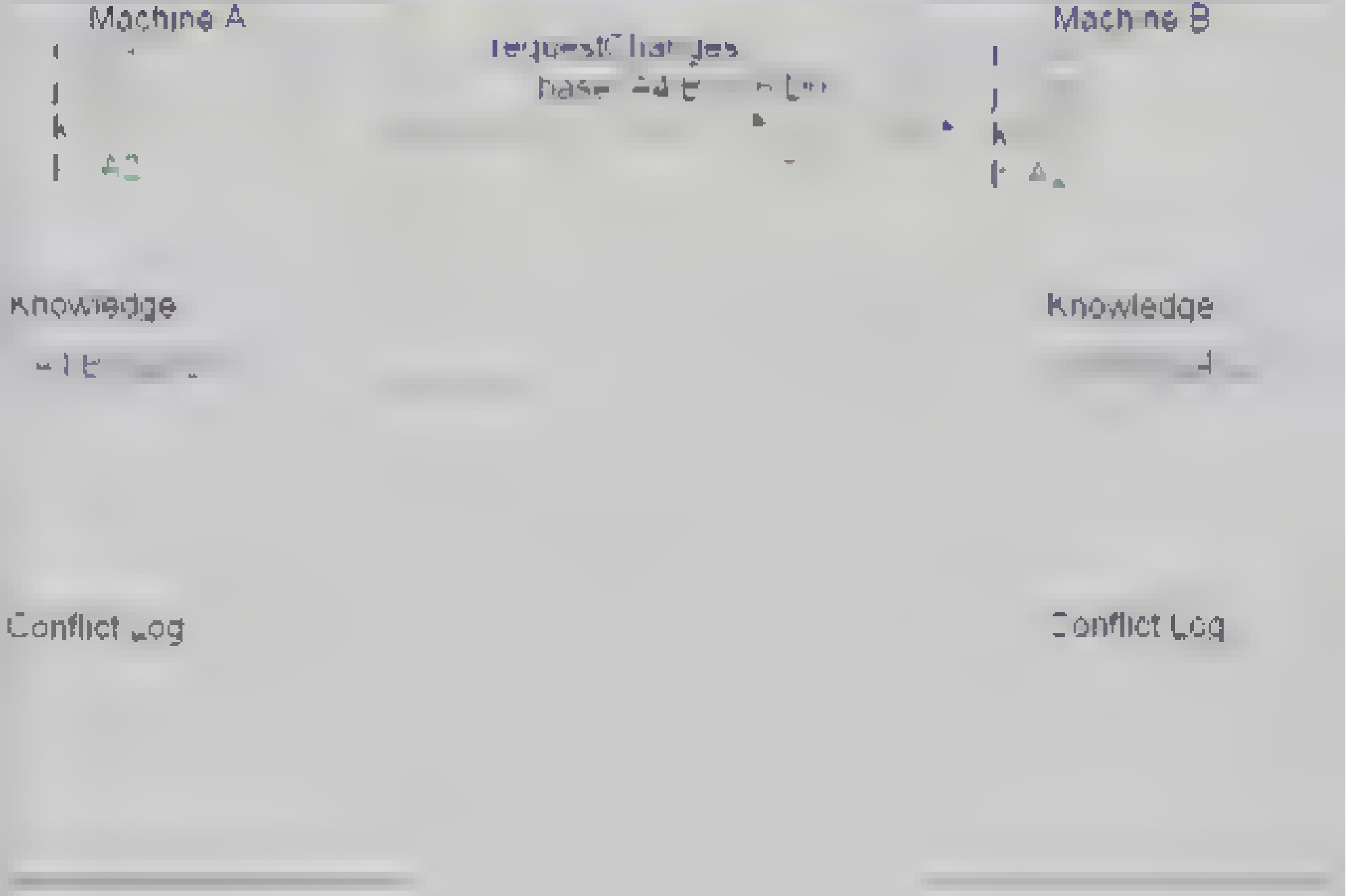


Protocol with Conflicts: Not Shown

- Automatic Conflict Resolution
  - [illegible]
  - [illegible]
  - [illegible]
  - [illegible]
- Storage Optimization
  - [illegible] conflict
  - [illegible]

Protocol with Implicit "Made With" Knowledge



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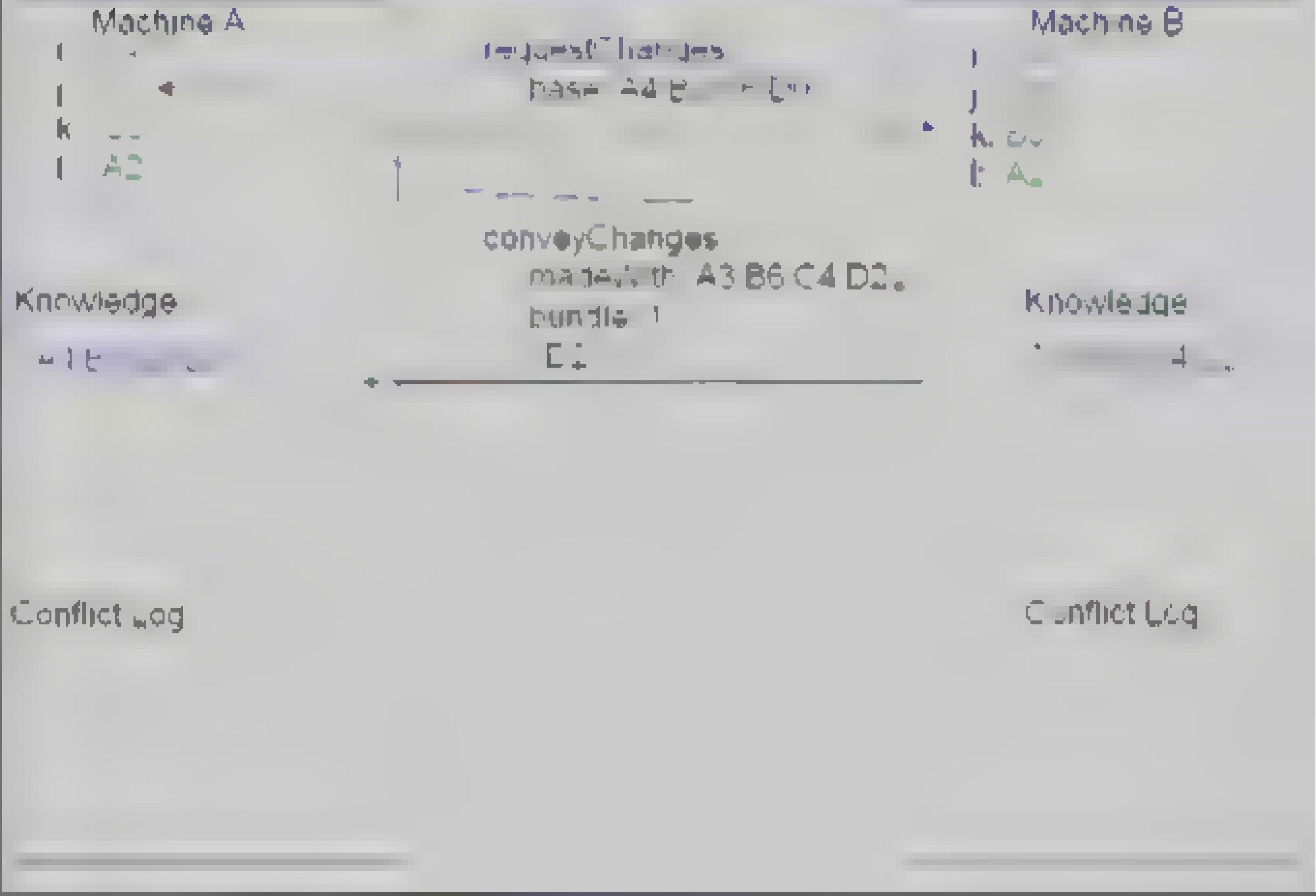

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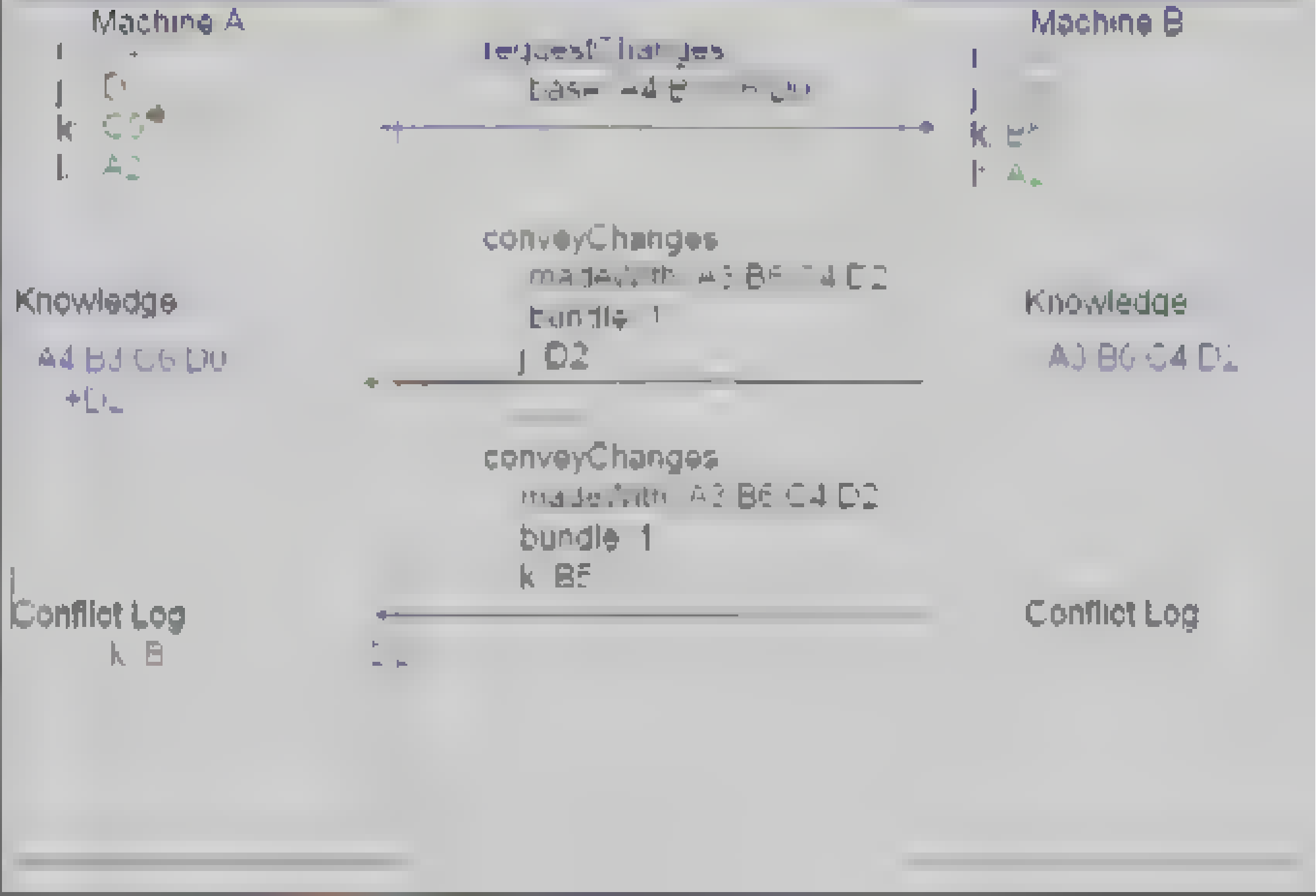

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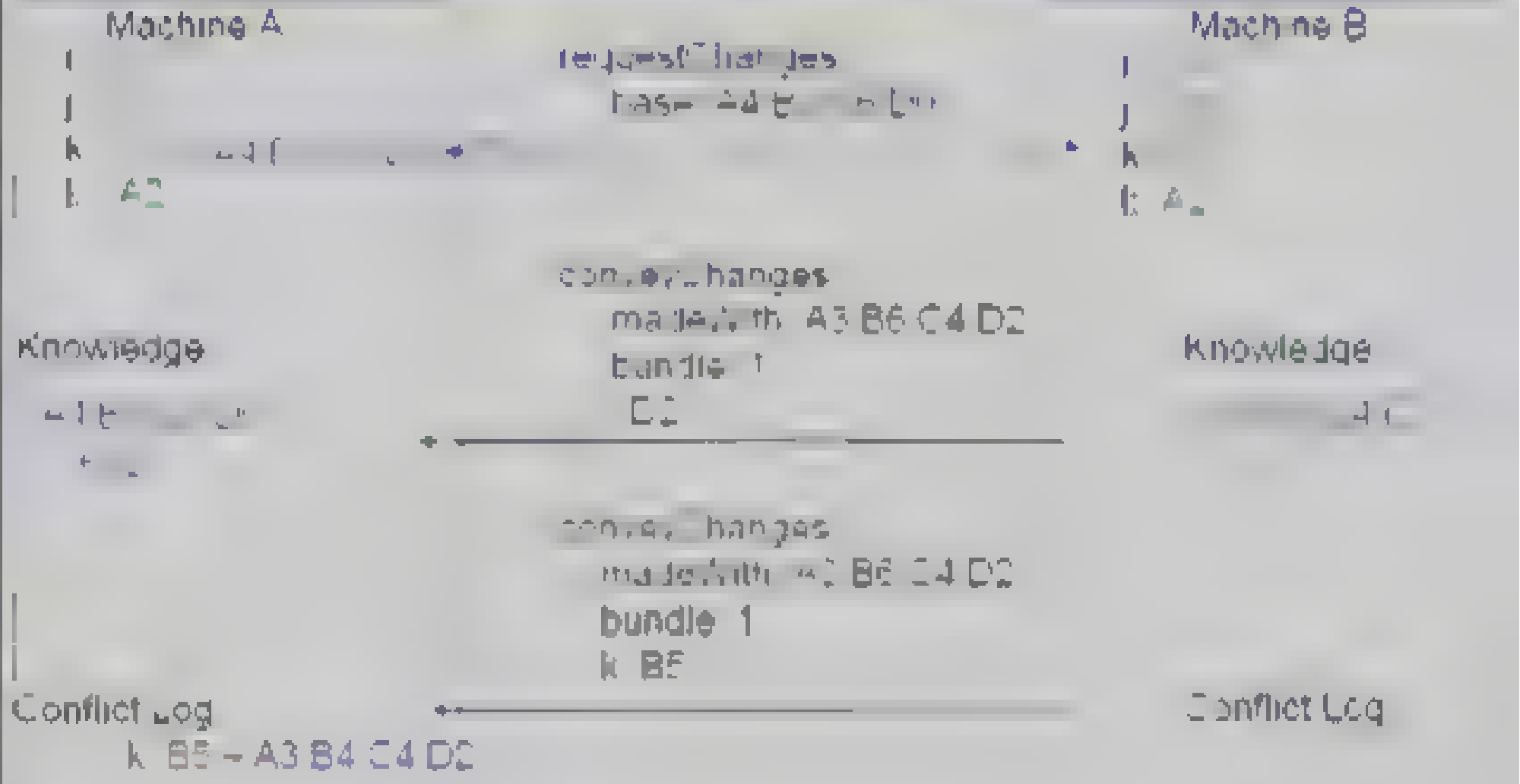

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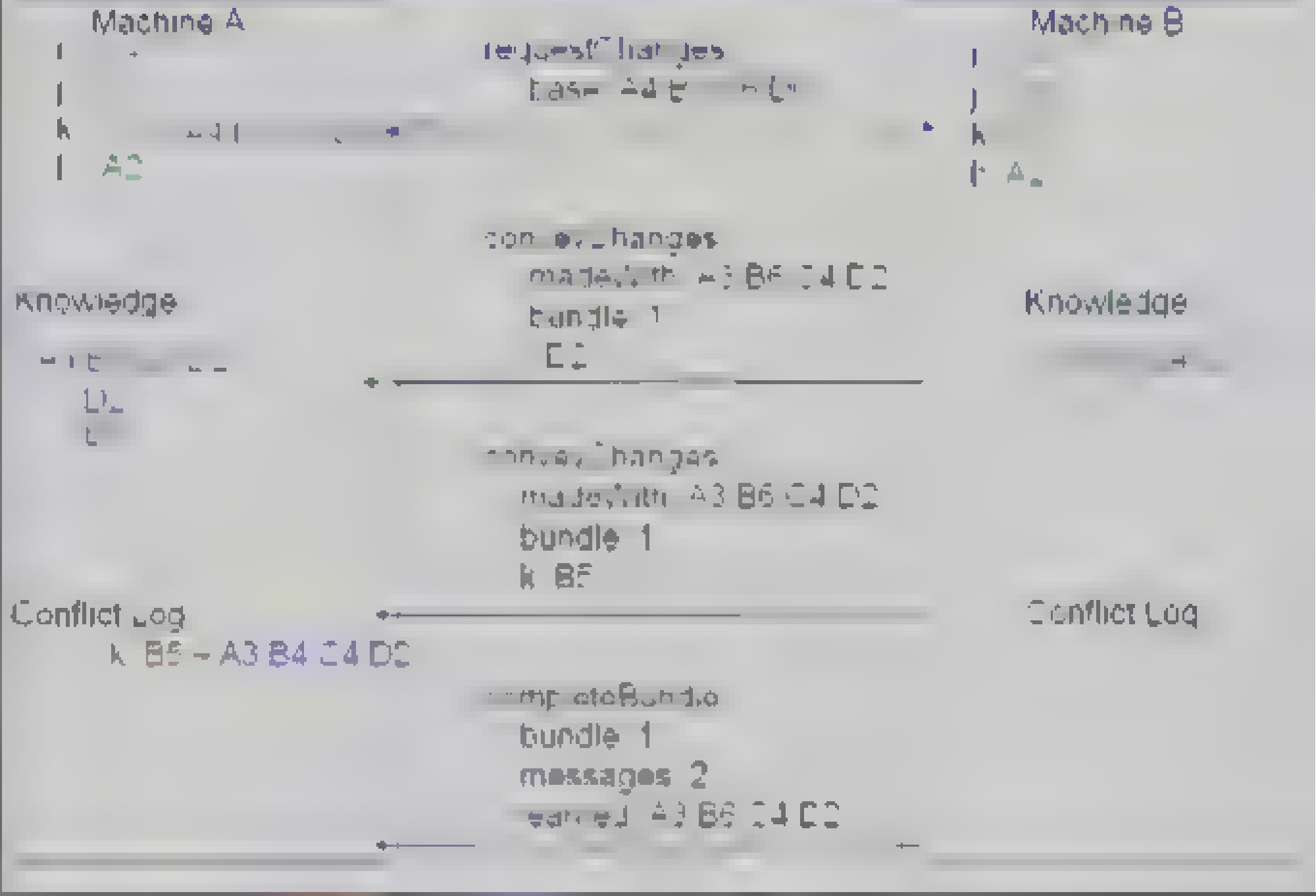

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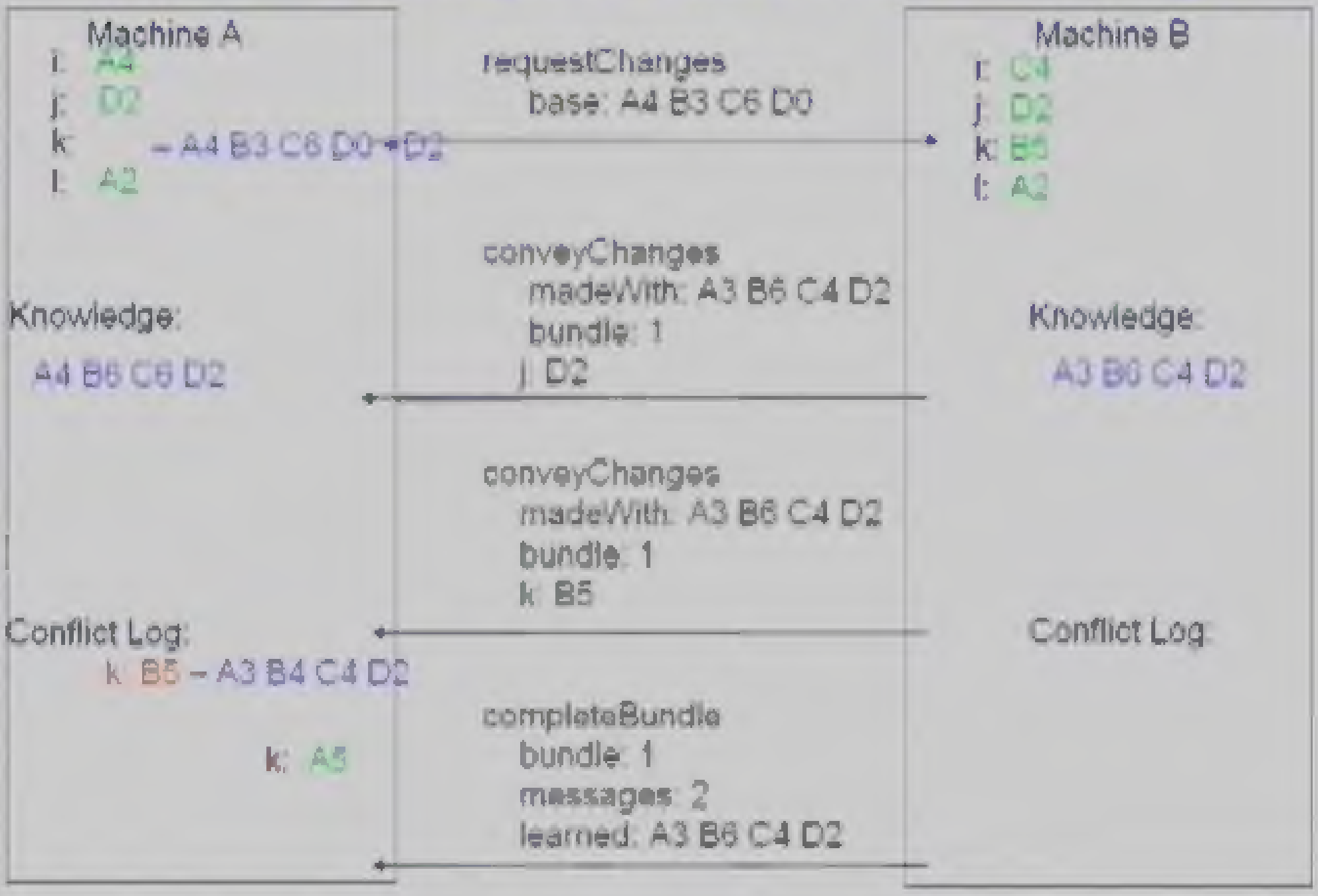

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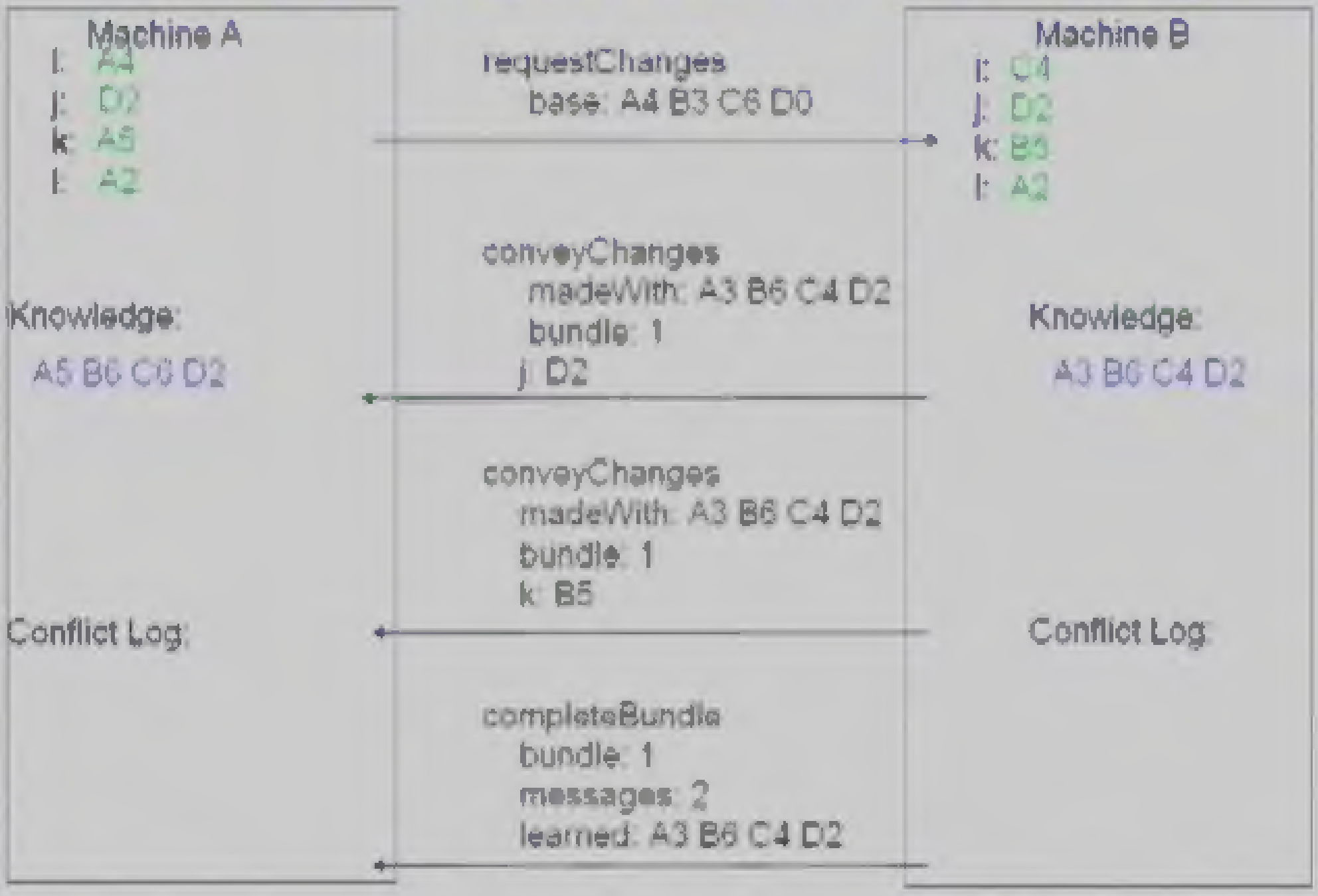

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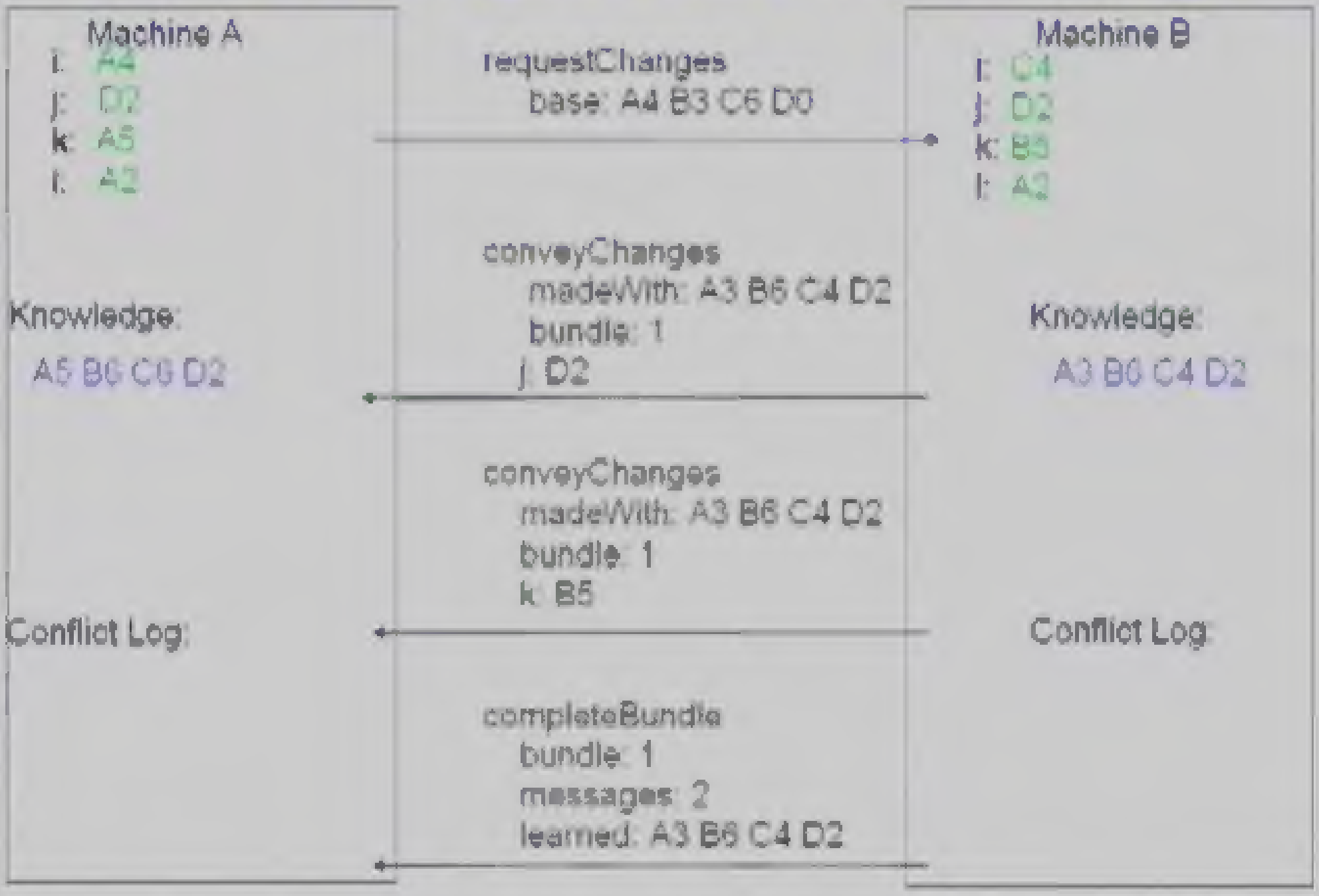

Summary

Key features of WinFS Synchronization:

- Favors availability over consistency
- Achieves robustness and scalability through pair-wise, knowledge-driven protocol
- Makes efficient use of bandwidth and storage
- Allows arbitrary communication topology
- Guarantees eventual convergence if well-connected topology
- Detects conflicts; permits manual or automatic resolution